SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) AN EXAMINATION OF THE XM-1 TANK SYSTEM ACQUISITION PROGRAM IN A PEACETIME ENVIRONMENT	5. TYPE OF REPORT & PERIOD COVERED Student Project Report, 74-1
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) GLEN W. WILLIAMS	8. CONTRACT OR GRANT NUMBER(s) May 74
9. PERFORMING ORGANIZATION NAME AND ADDRESS DEFENSE SYSTEMS MANAGEMENT COLLEGE FT. BELVOIR, VA 22060	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 57p.
11. CONTROLLING OFFICE NAME AND ADDRESS DEFENSE SYSTEMS MANAGEMENT COLLEGE FT. BELVOIR, VA 22060	12. REPORT DATE 1974-1
	13. NUMBER OF PAGES 49
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report) UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

UNLIMITED

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

SEE ATTACHED SHEET

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

SEE ATTACHED SHEET

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

4C 469

DEFENSE SYSTEMS MANAGEMENT SCHOOL

STUDY TITLE: AN EXAMINATION OF THE XM-1 TANK SYSTEM ACQUISITION PROGRAM IN A PEACETIME ENVIRONMENT

STUDY GOALS: To examine the XM-1 Tank program to determine the issues and problem areas which could impact on the program and analyze some possible alternatives.

STUDY REPORT ABSTRACT

The XM-1 Tank System program was initiated in 1972 as a follow-on main battle tank system to replace the M60 series tanks. This report is an examination of the current development plans; the historical experience of the MBT-70 program upon which the XM-1 draws; and the changing environment in which the development will be accomplished. The XM-1 Tank System is considered a moderate risk program because many of the major components are "state of the art." However, the program has many technical and management issues and problem areas. Considering all of the issues, the KEY issue is the criteria to be used to evaluate and select the winning prototype tank at the completion of the Competitive Prototype Validation Phase.

KEY WORDS: MATERIEL ACQUISITION ARMORED VEHICLES TANKS PROJECT MANAGEMENT

NAME, RANK, SERVICE	CLASS	DATE
Glen Wayman Williams, LTC, USA	PMC 74-1	May 1974

DEFENSE SYSTEMS MANAGEMENT SCHOOL

PROGRAM MANAGEMENT COURSE

INDIVIDUAL STUDY PROGRAM

AN EXAMINATION OF THE XM-1 TANK SYSTEM
ACQUISITION PROGRAM IN A PEACETIME ENVIRONMENT

STUDY REPORT
PMC 74-1

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WILLIAMS

AN EXAMINATION OF THE XM-1 TANK SYSTEM ACQUISITION PROGRAM IN A PEACETIME ENVIRONMENT

An Executive Summary
of a
Study Report
by

Glen Wayman Williams
LTC USA

May 1974

Defense Systems Management School
Program Management Course
Class 74-1
Fort Belvoir, Virginia 22060

AN EXAMINATION OF THE XM-1 TANK SYSTEM
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STUDY REPORT

Presented to the Faculty

of the

Defense Systems Management School

in Partial Fulfillment of the

Program Management Course

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LTC USA

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ACKNOWLEDGEMENT

The assistance of Mr. Sterling Purnell of the Defense Systems Mangement School is acknowledged for offering many helpful comments in the preparation of this study. In addition, considerable insight into the issues and problem areas was provided by members of the XM-1 Project Manager's office. I would particularly like to express my appreciation to LTC Joseph Ameel, XM-1 Tank System, Washington office for his assistance in providing access to files containing reference information.

CONTENTS

EXECUTIVE SUMMARY

The XM-1 Tank System program was initiated in 1972 as a follow-on main battle tank system to replace the M60 series tanks. This report is an examination of the current system acquisition environment, the previous MBT-70 development experience, and the XM-1 Tank System Development Plans. The XM-1 Tank System is considered a moderate risk program because many of the major components are "state of the art." However, the program has many technical and management review/approval issues and problem areas.

The results indicate that the key issue is the criteria to be employed to evaluate and ultimately select the winning contractor of the Competitive Prototype Validation Phase. The importance and validity of the criteria cannot be over emphasized since the proposed procurement is over $1 Billion and the XM-1 Tank System will be a key ground combat weapon for the remainder of the 20th Century.

The impact of the study is of direct interest to the project manager and his staff since the issues identified are of immediate and continuing concern to them. In the end, the issues and problem areas must be satisfactorily resolved by the Project Manager, XM-1 Tank System.

AN EXAMINATION OF THE XM-1 TANK SYSTEM ACQUISITION PROGRAM IN A PEACETIME ENVIRONMENT

Introduction

The XM-1 Tank System will be a full-tracked armored vehicle to be used as a primary assault weapon for ground combat for the remainder of the 20th Century. It will provide significantly increased performance over tanks currently in the inventory. It is considered a moderate risk program since many of the components have been in development for some time. The peacetime environment in which the development will take place is quite similar to that of its ill fated predecessor, the US/FRG MBT-70. The MBT-70 languished for 8 years in development before Congress killed it because of complexity and excessive cost. The MBT-70 program had been plagued by international and domestic political maneuvering, elusive requirements, funding problems, technological problems, and lastly schedule problems. The tocsin was sounded by Deputy Secretary of Defense David Packard in September 1969 when he testified as follows before the Senate Armed Services Committee:

> I suggest that the entire program be reviewed with particular emphasis on the question of what simplifications should be made in the design itself, how the program management could be improved, and what other possibilities there might be to bring the program into a more satisfactory position from which we might move ahead (3:1).

On 14 December 1971, the Congress directed the termination of the MBT-70 Tank Development Program. Funds in the amount of $20 million were made available for this termination. Also, Congress appropriated $20 million for a New Tank Prototype Program. Due to the arguments over the requirements and cost per unit, a reassessment of the requirement for the main battle tank system to replace the M60 series tanks was directed. The Commanding General of the Combat Developments Command was assigned the responsibility, who in turn further directed that a Task Force, chaired by a general officer be set up to develop a Main Battle Tank Program. The XM1 Tank Program is the resultant follow on program.

This paper will present the results of an examination of the current XM1 program, its issues, and potential problem areas. Any discussion of the XM1 Tank Program generally takes place against a backdrop provided by the MBT-70 Program. Therefore, some of the salient points and lessons derived from the MBT-70 programs also will be reviewed. This paper will be developed in four parts.

Part I is an examination of the systems acquisition environment within which the XM-1 Tank program was initiated and through which it must proceed to deployment. Recently, there have been significant changes in the acquisition process which should improve the management of major systems acquisition. However, forces external to the Department of Defense have an impact and affect the decision making process. The mood of the Congress, the country, our allies, as well as, potential adversaries will have an impact on the program .

Part II is an examination of the XM803 Main Battle Tank experience. This will include the early decisions to develop a new tank; a review of

major decisions throughout the development; and finally some lessons learned which must be put to constructive use.

Part III is an examination of the XM-1 Tank program development plans to the depth possible in an unclassified paper.

Part IV is an examination of the XM-1 issues and problem areas. These will be examined in light of cost, schedule, and technical performance criterion.

CHAPTER I

The Systems Acquisition Environment

The American people face an important decision today. The decision path chosen will have a major impact on our national security and our economic well-being for the remainder of this century. The decision is whether to spend limited resources on national defense programs or on other domestic programs.

The ever increasing costs involved in developing military materiel have been highlighted many times in recent years. Because development costs represent only "the tip of the iceberg", Department of Defense officials have been devoting ever more attention to all facets of the systems acquisition process. The need for more and better management tools has led to development of mathematical and quantitive methods of analysis such as decision theory, linear programming, operations research, and other similar techniques. These tools were first used extensively in DOD by former Defense Secretary Robert McNamara.

He incorporated these techniques to analyze complex problems and determine those factors most significant to the impending decision. At the same time, he emphasized that analytical techniques were not to substitute for sound judgement (9:15).

Under the guidance of Defense Secretary Melvin Laird, military judgement and expertise regained some of their previously lost influence. During his service as a member of Congress, Mr. Laird concluded that management

control in DOD was overcentralized. On assuming the position of Secretary of Defense, he set a goal of decentralization of these responsibilities. The military services and the Joint Chiefs of Staff were specifically tasked to determine force levels and the requirements for materiel to support them.

As the nation progressively became more and more disenchanted with the Vietnam War, Congress began to critically examine military expenditures and search out areas where costs might be reduced. Hence the military services have been constrained to work within ever decreasing defense resources ceilings.

About this time, Mr. David Packard arrived on the DOD scene as Deputy Secretary of Defense. In this role, Mr. Packard's philosophy of management fairly quickly began to unfold to the military services thru a series of memorandums reflecting emphasis upon the individual manager and with decentralization of the decision making.

His management philosophy was highlighted to the Congress in a statement before one of its subcommittees on 18 March 1971 when he stated:

> "My study convinces me that during the past few years, as programs got into trouble, OSD offices became too deeply involved in second-guessing the Services and in making over-riding decisions. Some programs were almost taken over by OSD. This clearly has not worked and I don't believe it can. The programs are simply too big and numerous for constant direct intervention and supervision by OSD offices to be effective. I believe we have made some progress in this matter. We reaffirmed that the Services have the responsibility for managing these programs and that the responsibility of OSD is one of establishing policy and evaluating performance. We are reserving to OSD the decision on whether a program is ready to go ahead at certain check points or milestones." (4:6)

Following upon this on 13 July 1971, Department of Defense Directive 5000.1 was published. This directive established policy for major defense system acquisition in the Military Departments and DOD Agencies. It is written in simple, straightforward language. It sets forth the policy that acquisition of major programs would be decentralized to the maximum extent consistent with the urgency and importance of each program, and that they would be managed by a single individual (program manager) who shall have a charter which provides sufficient authority to enable accomplishing recognized program objectives (5:1).

In keeping with the OSD intention to reserve unto the SECDEF the decision on whether or not a program would go forward, the DOD Directive 5000.1 specifically addressed the Development Concept Paper (DCP) and the Defense Systems Acquisition Review Council (DSARC). It states the SECDEF will make the decisions which initiate program commitments or increase those commitments. The DCP and the DSARC support SECDEF decision making (5:2). It is the approved DCP that governs the Service's development effort since it reflects the thresholds approved by the Secretary of Defense.

The Department of Army implementation of DOD Directive 5000.1 is set forth in Army Regulation 1000-1, "Basic Policies for Systems Acquisition by the Department of Army." The following six basic policies represent the framework for DA systems acquisition:

1. Shortened Requirements Generation Time.
2. High Level Decision Making.
3. Shortened Development Time.

4. Funding Priorities.
5. Cost Versus Quantity.
6. Program Cost Control (1:1).

As increasingly more sophisticated equipment becomes a must to insure superiority on the battlefield, its costs will be ever higher. It is the track record of the military services in providing this complex equipment that Congressional liberals cite as justification in their attempts to prune money from the DOD's annual budget requests.

The Fiscal 1975 Budget appears to reflect an increase in spending over Fiscal 1974, however this increase is eaten up by inflation and pay raises. The Army Research and Development budget will rise slightly to $1.945 billion which is sufficient to fully fund the Army "Big Five" (AAH, UTTAS, MICV, SAM-D, XM-1 Tank).

Recently, Adm Thomas H. Moorer, Chairman of the Joint Chiefs of Staff, told the Senate Armed Services Committee that the Soviet Union's modernization of land warfare weapons threatens the traditional U. S. assumption of superiority built on "pride in our superior weapons and equipment. "Recent evaluation of Soviet Tanks, armored vechicles, electronic warfare systems, and missiles indicates the U. S. technology gap which has favored the U. S. is being rapidly closed." (7:7) Inspite of overwhelming evidence that U. S. forces need substantial modernizing, Senator John C. Stennis has served notice that defense witnesses will be asked to justify their requests for funds, rather than taking up most of the committee's time solely with routine descriptions. He has also challenged the assumption that U. S. weapons development stood still during the Vietnam War.

While the U. S. was engaged with Vietnam problems, the Soviet Union spent enormous sums on the modernization of the armed forces committed to the Warsaw Pact and many Arab nations. Europe and the Middle East are well suited for tank warfare. Many people believe U. S. Forces should be withdrawn from Europe, yet this would be disastrous without concurrent equivalent withdrawals by the Soviets.

The Arab-Israeli War of October 1973 once again highlighted the importance of the tank as a weapon of war. Despite the antitank missiles used so effectively by both sides, military planners both western and Soviet still consider the tank the key weapon in ground combat. Therefore, no matter what the cost, the U. S. must be able to field a tank capable of dominating and defeating the enormous threat inherent in the armor of our potential adversaries.

CHAPTER II

The MBT-70 Development Experience

Start of a New Main Battle Tank

The development of a main battle tank is generally evolutionary; however, efforts were made in the MBT-70 program to incorporate many revolutionary ideas. The MBT-70 was to replace the M-60 series. The M-60 tank which was standardized in 1959 was basically a product improvement of tanks of Korean War vintage, based on a technology at least ten to twenty years old. It was apparent to the Army that the M-60 would not suffice as the MBT for the 1970s. Thus the U. S. Army Ordnance Corps had continued component development incorporating the latest known development in tank "state of the art." In late 1959, the Ordnance Corps formalized its component development in response to an approved Qualitative Development Requirement.

The Technical Development Plan, dated 2 May 1960, makes it apparent how far along was the concept for a new tank:

> The Main Battle Tank will be a full tracked combat vehicle in the 40-ton range mounting the CVWS (SHILLELAGH) as main armanent and employing radiological armor. The main armament will be automatically loaded and fired.

Also specified were the secondary armament, the power plant, as well as the type of suspension. The schedule at that time showed completion of engineering design by December 1963 and completion of testing and type classification by December 1964. Development funds for the program did

not include those for the Shillelagh weapon system since that system was not being developed exclusively for use on the Main Battle Tank (2:7).

By the beginning of 1961, the U. S. was well along on a unilateral new tank development, even while the need for and value of cooperative development efforts was being explored within NATO. By April 1962, the Department of the Army Staff and representatives of the Federal Republic of Germany (FRG) had established military requirements for a main battle tank and had discussed a joint research and development program. Development of the military requirement necessitated compromises because of basic philosophical differences. In late 1963, the U. S. and FRG Cooperative Tank Development Program was signed at the Minister of Defense level (2:9).

The agreement was quite comprehensive, specifying the scope of the program, details of management and organization, conditions for the exchange of information, patent rights and technical information. Both governments wanted to develop a tank to meet their operational requirements, which hopefully, would be acceptable to other NATO nations requirements as well.

The management scheme specified a Program Management Board, Program Management Offices, and Liaison offices. A key provision was that each government would have equal rights on the Program Management Board, that decisions would be unanimous; and that if timely agreement could not be reached the matter would be referred to higher authority immediately. One could see immediately built in to the agreement possibilities of cost escalation, schedule delays, and technical performance compromise. Unilateral withdrawal from the program was authorized.

Review of Major MBT-70 Program Decisions

The decision to develop any piece of equipment is driven by the approved requirement, and so it was with the MBT-70. However, the MBT-70 was selected for joint development for reasons other than just meeting the requirement. According to a DOD directive published about the time of the joint agreement, the objectives of the cooperative development were:

- To make the best equipment available to the U. S. and its allies in the most timely manner.
- To increase the effectiveness of scientific and technical resources of the U. S. and its allies, to eliminate unnecessary and wasteful duplication of effort.
- To achieve the maximum practicable degree of standardization of equipment.
- To create closer military ties among the alliance.

Therefore, the program was initiated with far more in mind than the combination of the capabilities of the two nations to develop a better tank than either could develop alone (2:43).

By the spring of 1969, the FRG proposed a vastly different design of the MBT for adoption. At this time the first pilot models were in engineering development tests. The FRG had decided to fulfill only part of their tank requirement with the MBT-70 and the U. S. Army was also looking at alternatives with a view to greater degrees of reliability and a reduction in the projected production costs. By the end of 1969 it appeared that neither nation was satisfied with the results to date. This was confirmed when it was announced on 20 January that the U. S.

and FRG had terminated the joint development on a single tank (16:A-10).

The joint cooperative development was plagued with many problems, but a single tank could probably have resulted if the projected production costs had not risen to unacceptable levels. Any future joint developments, whether total systems or components, should be aware of the following problem areas:

- National pride and capabilities to produce the item.
- Differences in employment philosophy of the item.
- Differences in required capabilities of subsystems.
- Management chain of approval.
- Differences in national development philosophy.
- Differences in contracting methods.
- Lack of common international standards, i.e., metric vs. English measurement systems.

Without going into great detail, it is fair to say that each of the above problems contributed to a degree to the ultimate cancellation of the MBT-70.

Duplication of development efforts or prototyping are acceptable ways of dealing with technical risk. But to avoid unwarranted expenditures, the developer must have the authority and be willing to make the decision which accepts a less than optimum alternative. The conditions and factors governing the decision should be well conceived and subject to minimum change. The noted English tank expert R. M. Ogorkiewicz has expressed the question quite succintly:

> "To the extent that it introduces an element of competition, the concurrent development of more than one design is bound to have a beneficial

> effect on the final product. But whether it is worth carrying it to the stage of competitive trials is doubtful, as it prevents serious production planning until a choice has been made between competing prototypes, as well as spreading the available resources between more than one project and to that extent slowing design and development." (10:149-150)

In the MBT-70 program, there was early consideration and development of advanced componentry in an effort to increase the life of the tank. Duplicate efforts were pursued mainly in the engine and suspension system. Each country worked on its own candidate systems. As development continued, each system (one metric - the other English) showed strengths and weaknesses, but each system continued as a competitor for final selection. As a result, each country gradually adopted a position in favor of its own candidate. Thus considerations for reducing technical risk were clouded by national and economic considerations, and finally became the overriding factors.

Early in the MBT-70 program, the Program Management Board, decided that a study was necessary to assist in determining design requirements and characteristics, and evaluating between alternatives. The study, known as the Parametric Design and Cost Effectiveness Study (PD/CE) was to apply the scientific approach to decision making. Although such studies had been used in the development of aircraft and missiles, this was the first time it had been used for tank development (2:17).

In March 1965, the Program Management Board met to select the MBT design concept for engineering development and major components necessary to proceed with the tank design. The tank design selected represented a

combination of the two variations which showed up best in the Parametric Design and Cost Effectiveness Study. However, an analysis and comparison of the recommended variations with those being pursued by the Ordnance Corps unilateral program indicate the study had little effect. But, the PD/CE Study was not a worthless effort since it was able to demonstrate analytically that certain actions were justified. General Dolvin, a former MBT-70 project manager, indicated that its greatest contribution was probably that a decision based on the study was better accepted by both the U. S. and Germany than if the decision had been made conventionally (2:57). Thus, again there is the lesson that the project manager was overly constrained by the political environment and concern for national interest.

The lessons learned from the MBT-70 program are not startling in themselves, but serve to point out "pot-holes in the road to success." The key lessons were:

1. That any significant departure in design from existing equipment must allow sufficient time in the schedule for concept selection.

2. Delays in selection of major components must be avoided if the schedule is to be maintained.

3. Any joint international development program, large or small, component or total system, can expect significant problems not normally encountered with national programs.

4. Cost estimating procedures must be improved, so actual costs are close to the estimates.

CHAPTER III

XM-1, THE MBT-70 FOLLOW-ON SYSTEM

Concept Formulation

The Main Battle Tank Task Force was established to develop a tank program for the U. S. Army. The initial mission of 4 February 1972 was subsequently changed until the final mission, as of 10 July 1972 was:

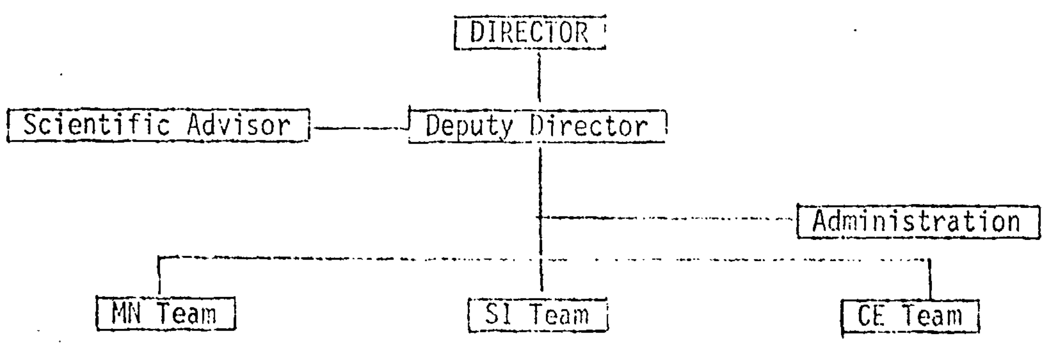
a. Continue to prepare a statement of Military Need (MN).

b. Continue to prepare an outline development schedule.

c. Prepare as complete a concept formulation package as possible, however the DA Staff would assume responsibility for an outline Army Tank Program.

d. Prepare the draft Development Concept Package.

The initial organization of the MBT Task Force was as follows:



The Material Need (MN) Team was assigned to prepare the Material Need documentation in accordance with AR 71-1.

The Systems Integration (SI) Team was assigned to (1) conduct design studies to describe feasible configuration alternatives, (2) conduct cost effectiveness analysis to recommend an optimum tank configurations,

and (4) documentation of the total analysis effort.

The Components Evaluation (CE) Team was responsible for determining the key components and characteristics which influence tank design, cataloging existing and development tank components, and assessing these components as to performance technical risk, required development time and cost.

On 28 March 1972 the Chief of Staff, U. S. Army, directed that the tank development program would be six years with the first unit equipped by 1978. This required changing the Task Force organization, the milestone schedule and the tasks.

To support the task force, study contracts were awarded to General Motors Corporation and Chrysler Corporation. These contracts were to provide inputs concerning technical, fiscal, and logistical areas. The contractors were tasked to derive feasible vehicle configuration, program schedules, program and unit costs, producibility analysis, and logistical and management concepts. In approaching these tasks, General Motors was directed to be innovative and Chrysler to be evolutionary. General Motors submitted eight vehicle configurations and Chrysler submitted three. Trade off determination and analysis were conducted and each contractor submitted his best technical approaches.

The contractor submissions, along with similar government agency inputs were used as source material in arriving at Task Force conclusions and recommendations (8:1-10).

The Concept Formulation Phase, which began with the establishment of the Task Force, extended through approval of Development Concept Paper No. 117 by the Deputy Secretary of Defense on 18 January 1973 (13:I.1). Proceeding to review by the Army Systems Acquisition Review Council (ASARC), there was considerable discussion concerning mobility, weight, and protection, as well as, a through scrubbing of other requirements. As a result, there was some modification of the Material Need (MN) band. The final Army position on system requirements, program plans, and costs was approved on 31 October 1972.

The Defense System Acquisition Review Council (DSARC I) review raised issues concerning the threat, program costs, and procurement plans, but did not result in any substantive changes in systems requirements. With respect to technical requirements, the DCP directs that the lower limits of the RAM-D MN Band will be program thresholds while all other requirements may be subject to trade-off in order to remain within a stipulated unit costs ceiling (13:II.10). From the action of DSARC I, it is apparent that unit costs and life cycle costs are of particular concern to OSD.

System Development Plans

The XM-1 Tank System is characterized by (1) exceptional battlefield mobility and agility, (2) rapid engagement of successive targets, (3) improved weapons effectiveness, (4) substantial improvement in fire control and target acquisition means, (5) effective target engagement while moving, (6) enchanced protection and decreased vulnerability, and (7) a capability to operate effectively during periods of darkness or limited visibility.

The development will stress the use of components which are considered moderate risk items. Moderate risk items are defined as off-the-shelf improvements or development items which are already in use in hardware having no major problems deemed incapable of timely resolution and on which test data exists (14:III-1). Development of the XM-1 will be conducted in three phases; Prototype Validation, Full Scale Development, and Production.

The Validation Phase will consist of a competitive prototype development by General Motors and Chrysler Corporations to establish the final component design approach, provide for initial development and operational tests of the prototype tanks, and to assist in the selection of one contractor to proceed to full scale development. Both contractors will be funded for long lead time items so competition and the overall schedule can be maintained. This phase is scheduled for 34 months.

During this phase the subsystems to be considered include: suspension system, engine, transmission, night vision system, stablization system, primary armament system, and the complementary weapon system. For the most part, the selection of the system to be proferred to the military for the competition will be a contractor decision in each case.

The suspension requirement calls for cross country operation at 25-30 mph will a high roadwheel travel suspension with improved damping characteristics over current production models. There are two approaches; the Hydro-pneumatic System and the Mechanical Torsion Bar and Tube System. Both systems have been extensively tested in the M-60 series tanks and the US/FRG MBT-70. The unit production costs of the two systems are relatively equal.

A high output engine is required to provide the mobility, acceleration, slope operation characteristics expected. The engine candidates include; a U. S. AVCR 1360-1 Diesel, AGT-1500 Gas Turbine, and a German MB-873 KA Diesel Engine. All of these engines are being tested in various other development programs of the U. S. and Germany. The 1500 HP requirement has necessitated modifications and extensive testing. Currently, the gas turbine option has not attained an acceptable level of confidence for use in the XM-1. The German Diesel Engine is currently being employed in the Leopard II Tank.

To provide for high power output, three transmissions, two U. S. and one German are being considered. The U. S. transmissions, X-100 and XHM-1500, are adaptable to diesel or gas turbine engines. Both have been tested extensively in the M-60 and MBT-70 programs by USATACOM. The German Renk HSL 354 transmission is currently being tested in the Leopard II tank by the FRG. There is no general acceptance of the Renk HSL 354 due to its weight and data package conversion problems.

The Night Vision requirement is being actively pursued on several fronts and all possible approaches are being considered. Contractors will make tentative night vision system design selections in the validation phase; however, actual hardware will not be evaluated on prototype vehicles.

The stabilization system currently requires more development. Two approaches are in use today. One type mounts the gyro directly to the main weapon and the other integrates the gyros into the sight head. Both systems have been extensively used in modern tank programs.

The Primary Armament System must be in the caliber range of 105mm-120mm and be optimally designed to fire a kinetic energy round. The U. S. is currently participating in a joint evaluation of several tank guns of the 105-120mm caliber.

The complementary weapon system must provide a capability to engage personnel, lightly armored vehicles, and low performance aircraft. The approaches currently being considered are the .50 caliber machine gun, the 7.62mm machine gun, and the 20-30mm Automatic Cannon. The machine guns are type classified standard A and the cannon is still in development. It is expected that the cannon will ultimately be the complementary weapon system to be used on the XM-1 tank system; however the .50 caliber machine gun will be used during the Validation phase.

Testing in the Validation Phase will consist of a series of component development tests and evaluations to include subsystem integration. The contractors will determine if the components are suitable for use in the prototypes. Each contractor is to build one automotive test rig, one prototype vehicle, and one ballistic hull and turret for competitive evaluation in DT 1/OT 1. The competitive test approach will provide an assessment of the performance issues; establish the final system and component approach; and assist in the logical selection of a single contractor for Full Scale Development. The user will also get an assessment of the relative effectiveness of the system compared to the existing U. S. tanks.

The cost, schedule, performance, and management controls will emphasize maximum contractor responsibility and flexibility during the

Validation Phase. Cost estimates will be required three times, at the 12th, 20th, and 28th month of the validation period. Schedule and cost will be monitored thru Cost/Schedule Control System Criteria. Unit hardware costs and performance are of paramount concern in each tradeoff by the contractor. The contractors must accept total system responsibility since the government is not dictating the use of any specific components except the armament which is GFE. There is no contractual requirement to meet all of the technical characteristics except for RAM-D, weight, and width, but the contractors must make their best effort and keep in mind the competitive evaluation at the end of the phase. Each is required to submit a proposal and program plan for the following Full Scale Development phase (14:7-23).

During the Full Scale Engineering Development phase the contractor will complete the development and testing of prototypes to include operational testing by the user. Full Scale Engineering Development will consist of two phases, Engineering Development (ED) and Producibility Engineering and Planning (PEP). Sincere there will be eleven pilot vehicles available in this phase, the user will have an opportunity to thoroughly test the total system, and an evaluation of RAM-D characteristics and design changes can be accomplished prior to production.

In Engineering Development, the contractor will refine and submit a system and component specification to the government. Development and test of new armor configuration and compartmentalization techniques will continue emphasizing producibility and cost reduction techniques.

During Producibility Engineering and Planning (PEP), the producibility of the tank design, plant layout, planning for long lead time items, and preparation of the technical data package will be considered. This phase will extend for a period of 23 months of the total 38 months planned for Full Scale Engineering Development (14:25).

Testing during this phase will include early design tests and later Development Tests (DT) II and Operational Test (OT) II. The early Engineering Tests will insure that the components meet the specifications and all deficiencies found during DT I/OT I have been corrected. DT II will be conducted by USATECOM in three phases; Engineering, Service, and Environmental. OT II Testing will be conducted by the Army's Operational Test and Evaluation Agency to provide data concerning availability, reliability, and maintainability.

In Full Scale Development, the contractor will be required to use a System Engineering Management Plan (SEMP) and a Cost/Schedule Control System Criteria to control and track the costs and schedule.

The Production Phase will begin after a DSARC IIA decision with an Initial Low Rate Production run. This will provide 8 vehicles for DT III/OT III tests and preparation of a sound technical data package. DT III testing will verify the adequacy and acceptability of the XM-1 when manufactured by production specifications. During OT III, 54 of the initial production vehicles will participate in a battalion size operational test in a mid intensity combat environment. The data from DT III/OT III will provide a basis for the ASARC/DSARC III decision to proceed to full production (14:III.33).

Management of the XM-1 Tank System is vested in the Project Manager. The Project Manager's Charter, dated 18 July 1972, delineated his mission and specific authority and responsibilities. The project manager reports directly to the Commanding General, U. S. Army Materiel Command (USAMC), since the XM-1 Tank System is one of the Army's "Big Five". The Project Manager's office is a matrix organization and consequently staffed with 16 military and 62 civilian personnel. This minimum staffing is in consonance with AR 70-17 and provides the required personnel to accomplish the management functions (14:III.49).

The management methodology will be guided by the principles, policy, and procedures set forth in DOD Directive 5000.1. A single Work Breakdown Structure (WBS) provides the framework for planning, control, and reporting of progress. Contractors will be allowed to use their existing management systems as long as they meet the DOD Cost/Schedule Control Systems Criteria set forth in DOD Instruction 7000.2.

Formal system engineering management requirements will not be applicable until Full Scale Engineering Development (FSED). During the Validation phase each contractor will deliver a System Engineering Management Plan (SEMP). Included in each contract is the requirement for a Technical Performance Measurement (TPM) to provide for identification, quantification, and tracking of critical parameters.

The physical and functional characteristics will be controlled thru Configuration Management (CM). During the Validation phase there will be no formal Configuration Management. During Full Scale Engineering Development CM, will control the Functional Baseline and establish the Product Baseline. In Production complete design control will be applied.

Integrated Logistics Support (ILS) development and control will utilize the Standard Integrated Support Management System as required by AMCP 700-4. During Validation, ILS will be confined to development and formulation of plans. In Full Scale Engineering Development, complete data collection and development will occur.

The Financial plans for the XM-1 Tank System are established in accordance with USAMC regulations. A detailed planning cost estimate is included in the System Development Plan and tracks all estimates from the MBT Task Force figure up to the approved program reflected in the current DCP. It constitutes the program baseline for future cost tracking and analysis. The Parametric Cost Analysis conducted by the MBT Task Force included program and unit costs. Development costs were derived through analogy with the MBT-70 program based on a projected schedule and program. Operating costs were derived in part from studies conducted by USAMC and USCDC concerning the M60 family.

Cost thresholds are established in the DCP for Research and Development, Test and Evaluation (RDTE), Procurement Equipment and Missiles, Army (PEMA), and Unit hardware cost. The unit hardware cost ceiling is $507,000 which converts to a "Design to Cost" goal of $430,000 for the contractor. The Request for Proposal presented the $430,000 as a range of $400 - 450K. This cost parameter is to be a driving factor in all cost/performance tradeoffs (14:III.55).

The XM-1 will be procured in three phases; Competitive Prototype Validation, Engineering Development/Producibility Engineering and Planning (ED/PEP) and Production. The prototypes are being procured under

two Cost Plus Incentive Fee (CPIF) contracts which incentivize cost only. At the end of the competition, one contractor will be selected for ED/PEP and this effort will also be a Cost Plus Incentive Fee contract with the incentive on cost only. After satisfactory testing, in DT/OT II, the initial production will be procured under a Fixed-Price Incentive contract with Successive Targets (FPIS) (14:III.65).

The XM-1 procurement scheme is set forth in detail in the Advance Procurement Plan. Source selection will be conducted in accordance with DOD Directive 41052.62, AR 715-6, and AMCP 715-3. As required by DOD Directive 4105.62, the Secretary of the Army is the Source Selection Authority (SSA). Contracts are being negotiated under the authority of 10.U.S.C. 2304 (a)(11) and paragraph 3-211 of the Armed Services Procurement Regulation because the procurement is for services and prototype vehicles incidental to development and test. Procurement by formal advertising, including two-step advertising, is not feasible because the work to be performed cannot be described in sufficient detail. A determination as to the extent of breakout for production will be made in ED/PEP, and in initial production it will be minimal to insure maximum contractor responsibility for the system (14:III.J.18). In addition to the two competitive prototype contracts, there is approximately $15 Million in active contracts supporting development of components for the XM-1. All of the contracts are Cost Plus Fixed Fee (CPFF).

The XM-1 schedule is considered optimistic in light of past tank system developments. However, the Army Chief of Staff, General Abrams, directed that the system be in production in 6 years, and this is bound to speed up decisions within the Army and provide the necessary impetus

to complete DT/OT expeditiously. OSD has approved the schedule and established the schedule threshold as a 9 month slip in any major milestone (14:III-67).

The general schedule is shown below.

Calendar Year	73	74	75	76	77	78	79	80	81
Validation Phase	----	----	----						
DT/OT I			-	--					
DSARC II				V					
Full Scale Devel Phase				----	----	----			
DT/OT II					----	----			
DSARC IIA						V--V			
Production Phase									
Low Rate Initial Prod						----	----		
DT/OT III							----	----	
DSARC III								V	
Full Production								----	----

The Coordinated Test Plan for the XM1 summarizes the tests and evaluations planned from the concept through early production. It provides an outline of the tests necessary to insure that the XM1 system and its related equipment comply with the requirements stated in the Material Need Documents. Each phase of testing is designed to resolve and answer questions and critical issues for scheduled ASARC/DSARC decisions. The broad categories of tests are: Development Testing (DT) and Operational Testing (OT). Development Tests provide the data required to resolve the critical issues and determine design suitability and technical

acceptability and readiness of the system to proceed to the next phase of development. Operational Testing provides data to determine the operational suitability of the system from the point of view of doctrine, organization, and tactical suitability.

Development Testing and Operational Testing may be conducted jointly, but normally they will be conducted separately. In the case of XM1, DT/OT I will be a joint test. This test will be under the direction of a Joint Test Group established to conduct the competitive evaluation of the candidate prototypes. The group will be composed of representatives of Test and Evaluation Command (TECOM), Operational Test and Evaluation Agency (OTEA), Training and Doctrine Command (TRADOC), and the XM1 Project Manager Office. This will allow direct input and participation of the user in the competitive evaluation. The results of this test will be used by the Source Selection Evaluation Board in selecting the one contractor to continue Full Scale Engineering Development (15:V1).

CHAPTER IV

AN EXAMINATION OF THE ISSUES AND PROBLEM AREAS

General

In any development, the primary issue is to achieve a balanced design between performance and cost within schedule constraints. With the XM1, this requires that the contractor propose a "design to" average unit hardware cost of $400-$450K for production vehicles excluding specified GFE, within a schedule of 6 years which must not be lengthened. If this schedule is to be maintained, then one can reasonably assume that performance may be traded off as increasing costs cause budget pressure to mount and technical problems arise. However, tradeoffs in performance have a limit that cannot be exceeded. The Technical Development Plans state that tradeoffs in performance must not result in a system offering no improvements or only marginal gains in performance over existing U. S. tank systems. A marginal gain would mean only performance probably equal to that of the Product Improved M60A1 Tank on a subsystem (i.e., firepower, mobility, and protection) basis. If the contractor cannot achieve a weapon system design which meets the desired technical characteristics within the stated hardware cost range, he will be allowed to tradeoff performance outside the MN band in the following descending order of priority:

1. Crew Survivability (all aspects).
2. Surveillance and target acquisition performance.
3. First and subsequent round hit probability.
4. Time to hit/kill.
5. Cross country mobility.

6. Complementary armanent integration.
7. Equipment survivability.
8. Environmental.
9. Silhouette.
10. Acceleration/deceleration.
11. Ammunition stowage.
12. Human factors.
13. Producibility.
14. Range.
15. Speed.
16. Diagnostic aids.
17. Growth potential.

In examining the environment, the MBT-70 development history, and the XM1 development plans, the issues and problems fall into two broad categories: (1) technical and (2) management review and approval.

The technical issues to be resolved are:

1. Are the reliability, availability, maintainability and durability values set in the DCP as thresholds actually attainable?

2. Is it really in the U. S. best interest to consider the use of foreign components and technology?

3. Are the subsystem components being considered actually moderate risk approaches?

4. What is the maximum protection achievable within the weight established in the MN?

The management review and approval issues to be resolved are:

1. What is required to meet the threat?

2. Is it desirable to fund two contractors through Full Scale Engineer Development to obtain the best tank for the money?

3. What type of contract is best for the Production Phase?

4. What criteria will be employed during the competitive Validation Phase to evaluate and finally select one of the prototypes for Full Scale Engineering Development?

Considering all of the issues, the key issue is the criteria to be used to evaluate and select the winning prototype tank in the Validation Phase. To be sure, it can be expected that both General Motors and Chrysler

Corporation will do everything within their power to win a contract that will lead to a production contract worth more than $1 billion.

Technical Issues

The Reliability, Availability, Maintainability, and Durability (RAM-D) requirements are:

Reliability - Overall vehicle 320 MMBF (Mean Miles Between Failure)
Maintainability - Maintenance ratio shall not exceed 1.25*
Availability - Inherent 89%**
Durability - Power train 4000 miles***

* This ratio is expressed as maintenance manhours divided by vehicle operation hours at 7mph.

** Availability is a mathematical computation of MMBF divided by MMBF plus MTTR. Mean Time To Repair is the arithmetic mean of the maintenance times to repair the chargeable mission failures.

*** .50 probability of completing the distance without replacement or overhaul of any major components.

In concluding its mission, the Main Battle Tank Force analyzed the logistic data of the M60A2 ET/ST (Engineering Test/Service Test) and concluded the RAM-D requirements are attainable goals. Life Cycle Cost Analyses conducted during the same period seem to indicate that the values are reasonable. However, the balance between these requirements and other design considerations are entirely in the hands of the contractor with government reliability and maintainability personnel assessing the progress at the end of each testing phase. During DT/OT I no specific RAM-D tests are programmed; however, a qualitative analysis of the failures will be conducted and corrections assessed. In DT/OT II, 85% of the specified requirement must be demonstrated. If the contractor is able to meet what seem like reasonable requirements, then the impact on

cost and schedule will be minimal and the technical performance of the XM1 will be superb.

The use of foreign components and technology in our weapon system developments has a philosophical and logical ring to it, but one might ask if perhaps the price isn't too high. However, this may be a mute point, considering the following statement by former Secretary of Defense Laird; "The severe competition for national resources makes it virtually impossible for the U. S. to plan to retain technological superiority across the full spectrum of defense technology all by itself." This indicates that the U. S. will depend upon its Allies as a source for some of its developments. At the same time, Mr. Laird said, "this dependence wouldn't affect our economy because we would intend to produce any selected Allied weapons here in the U. S. " (11:453). Essentially, U. S. contractors would obtain licenses for production of promising tatical weapons, and then after extensive testing, the weapons would be built by U. S. firms to insure a domestic production base. Agreements of this nature are concluded under the Military Assistance Program, whereby the foreign government agrees to furnish foreign patent rights, technical assistance to include data, know-how, trained personnel for instruction and guidance, jigs, dies, fixtures, and manufacturing aids to assist in the development and establishment of a production base. While appearing to offer a more simplistic solution in a time of changing priorities, limited funding, and tenuous political alliances, nonetheless, a course of National independence in weapons development appears far better than depending on our Allies. To be sure any agreement will have strings attached probably in the form of reciprocal agreements, taxes, political constraints, and technical

tradeoffs. However, in spite of such potential problems, foreign weapon components and systems are continually under test to assess their worth as possible candidate subsystems. The XM1 candidate components have been characterized as presenting moderate risk and having no major problems deemed incapable of timely resolution. Candidate components include German and U. S. developments either initiated or developed in the MBT-70 program or the German Leopard II program. Due to the extensive testing of all components technical risk is considered minimal, but we should not lose sight of past experience wherein scaling up and integration of subsystems always seems to encounter problems far greater than any of those anticipated.

The Hydro-Pneumatic Suspension System, formerly used on the MBT-70, is being redesigned to conform to XM1 requirements and reduce production costs, and currently few problems are expected.

There are three engine candidates including two diesels and one gas turbine. The U. S. diesel, AVCR 1360-1, has been augmented with superchargers to increase horsepower and lower speed torque, yet we must not lose sight that these modifications are unproven, so durability must still be demonstrated and assessed. The turbine has been tested extensively as a power plant for 55 ton vehicles, but testing at the 1500 GHP level is not complete. With the political and economic pressure that is on the XM1, there will be much second guessing of any concept which selects the turbine as the power plant for this tank. The turbine's cost and technical risk are considered marginal at this time. The German diesel, MB-873 KA, being tested with Leopard II tank chassis is considered a viable powerplant

for vehicles in the 55 ton range. However, its selection must be tempered by the foreign item considerations set forth earlier.

The transmission candidate models include 2 U. S. and 1 FRG. The U. S. models, X-100 and XHM 1500, are adaptable to diesel or gas turbine engines. The X-100 is considered a moderate to high risk component since it is still in early development although the concept has been demonstrated. The XHM 1500 was fabricated successfully under the MBT-70 program and should be considered moderate risk. The FRG, Renk HSL 354, transmission has exhibited good reliability and durability, but due to its large weight compared to the X-100, it has not been accepted completely, as yet, by the development community. Therefore, in consideration of the foregoing, the transmission components are considered as involving moderate to high technical risk.

The user can be expected to ask, "What is the maximum protection afforded by the tank." The degree of protection is a function of the amount and quality of armor plate. But the maximum vehicle weight is 58 tons, and this can be expected to cause the contractors some problems. The upper weight limit of 58 tons is non-negotiable, so performance and protection tradeoffs can be expected if problems arise. Research and development of new types of armor alloys are continually being pursued, but most are considered moderate to high technical risk areas. However all is not lost, since in over 50 years of tank evolution the technology of armament systems has outdistanced the technology of armor protection, but tank design has kept pace and provided the necessary balance between the two. If new armor arrays or alloys should become available then one might expect the cost of the tank to increase.

Management Review and Approval Issues

At every decision point and every review, the question of threat, and what is required to meet it are discussed in some detail. This is to be expected when one considers the length of time required for the development of a tank. The XM1 is being designed to meet the threat currently posed by our most probable future adversary. There is ample and sufficient evidence of evolutionary improvements having been gained by that adversary in mobility, agility, and combat survivability of their opposing tank fleets, to make it mandatory that the XM1 be sufficiently sophisticated to compete and be victorious in any future confrontation.

A sneak preview of the nature and intensity of the battlefield of the midrange future was provided by the October 1973 Middle East War. It will probably be years before the lessons and full implications of that war are sifted, examined, evaluated, and assessed. However, one thing which is abundently clear from observer reports is that the level of sophistication exhibited by the Arabs clearly reflects utilization of superb tactics and excellent Soviet weaponry. The devastating accuracy of U. S. as well as Soviet antitank guided missiles once again raises the issue: Is the tank obsolete? Most military experts seem to indicate that No is the answer. As long as a potential adversary plans to employ tanks, the U. S. must have a superior counter-capability, no matter what the cost. Colonel A. A. Sidorenko, Doctor of Military Science, Frunze Military Academy, recently gave the world an example of Soviet thinking when he stated: "The breakthrough of a prepared defense, if the enemy undertakes it, will be accomplished not by gnawing through as happened in the last

war (WW II), but by launching of nuclear strikes and overcoming it from the march and at high rates by the tank and motorized rifle troops." (12:17).

To hopefully obtain a superior product, the competitive prototyping concept has many supporters. But when does one stop prototyping, and continue into production and deployment of the item? The XM1 program currently plans for a competitive prototype Validation Phase and then the contractor who wins the competition will continue the program through Full Scale Engineering Development and Production. There are those who suggest that fully funding two contractors through Full Scale Engineering Development would drive the ultimate cost of the tank down while insuring a better tank. The cost of allowing such a course of action is an estimated additional $200 Million. It is doubtful if this course of action would significantly alter the estimated unit production hardware cost, although a competitive atmosphere would be maintained. This alternative would almost certainly slip the schedule because Producibility Engineering and Planning would be hampered and Integrated Logistic Support Planning would be delayed. In the final analysis, to extend the competition through Full Scale Engineering Development would increase the costs, slip the schedule, and result in approximately the same quality tank as currently expected.

The type of contract and the tightness of the schedule of decision points for initial production and full scale production will determine the ultimate cost and schedule for the XM1. The general schedule calls for PEP activities, DT/OT II testing, DSARC IIA decision point, and Initial Low Rate Production to overlap during late 1978. The concurrency of these

activities could significantly impact the program costs and schedule depending on the results of DT/OT II. The key to this phase is the results of DT/OT II, and the attitude and their evaluation by the DSARC IIA. If approval is obtained to enter initial production, a Fixed Price with Successive Targets (FPIS) contract might be utilized. Recognizing the risks to the contractor and the government, the monthly production rates would be minimized (consistent with the test requirements for production vehicles) until the hardware changes and tooling changes are determined. The FPIS contract is considered appropriate for this situation since all of the costs are not firm.

It is planned that the Full Production will be awarded to the FSED developer and that production will be performed in the Detroit Arsenal. This is expected in 1981, after a DSARC III evaluation of DT/OT III test results and approval to proceed. It is anticipated that a Fixed Price type multi-year contract will be utilized. By that time, negotiations can be based on data collected during the initial production phase and "should cost" techniques. The contract types which seem applicable to the XM1 are Fixed Price with Escalation (FP-E), Fixed Price with Incentive Fee (FPIF), and Fixed Price with Prospective Price Redetermination (FPRP).

The FP-E contract seems applicable since the environment and rates of inflation for the production period can be estimated at roughly 10-12 per cent and the labor and material situation can be forecasted. This contract would not encourage the contractor, however, to make significant efforts to reduce costs of performance. The government could expect the contractor to negotiate the price on the high side to maximize his profit.

The FPIF contract is probably the best type of contract since it is flexible, provides an incentive for the contractor to reduce costs of performance, and allows the contractor and the government to share the benefits or burden of cost of performance changes. This could easily be administered and monitored since both prospective producers have accounting systems which permit the application of price and profit adjustment formulas.

The FPRP is applicable since it is possible to determine fairly accurately a fixed price for the early years, but one could expect to encounter difficulty in forecasting the National economic situation in the late 1980s. This might appeal to the contractor since he would be able to maximize his profits in the early stages by cost of performance reductions. However, negotiation of the later contract might be more difficult.

Since the probability of competing the production contract is slim, the FPIF contract appears to provide the best chance of the program remaining within cost, performance, and schedule thresholds.

The guidance for the selection of contractors for major defense systems is found in the proposed DOD Directive 4105.62, "Selection of Contractual Sources for Major Defense Systems." The directive will cause significant changes in the source selection process, and clarify several areas. The draft directive has been closely scrutinized by the Council of Defense and Space Industry Association (CODSIA), and they provided the following comments on four topics which should be considered before the directive is approved:

"1. Achieving more realistic and credible contracts by avoiding parallel negotiations with competitors, which otherwise has the harmful result of technical "leveling", cost auctions, and improvident contracting.

2. Provide competitors with maximum understanding of the Government's objectives, requirements and goals in order to streamline, speed, and assure impartiality in the source selection process. Clear and adequate evaluation criteria for selecting the winner must be provided and well identified in the RFP.

3. Screen solicitation and contract requirements to improve cost effectiveness through the program and closer contractual compatibility with the nature of the specific procurement.

4. The contracting officer's role in the business aspects of proposals and contracts and as the government spokesman to contractors must be clearly understood by all management levels and enforced to the maximum extent." (6:A-10)

It is obvious that CODSIA also considers the evaluation criteria of the utmost importance. They also warned that the DOD language was so broad that it could only lead to "further technical transfusion or leveling and cost auctions which the government and the contracting community wish to avoid."

At the conclusion of the competitive validation phase, a determination will be made as to which contractor's prototype won the competition. This will be based on an assessment of the results of prototype testing, an evaluation of the potential design to meet program requirements, and the adequacy of the proposal for performance of the Full Scale Engineering Development contract. The detailed criteria, currently being considered by many, should be detailed, objective, and discriminatory.

The first area is what should be the proper balance between the technical and the management and cost areas. Once this is established, then critical subelements can be identified and weighted. Given the moderate technical risk of the program, it would seem that a 60/40 balance

between technical, and management and cost would be appropriate.

To evaluate the technical areas, the developer and the user must clearly delineate what the test objectives are and what standard is to be used. DT should use the specifications, while OT should use the projected operational doctrine, tactics, and organization for the future.

The scoring system will be questioned by many, so it must address what the competitive range is, and how deficient areas will be evaluated and scored. Within the competitive range, it will be necessary to discriminate between close proposals. A pass-fail type of criteria will probably not suffice.

In the final analysis, the role of the Project Manager in the source selection process will be most important. If he is appointed by the Source Selection Authority to direct the evaluation process, then the level of acceptability of the selection would be improved. Due to the size of the development and procurement, one can expect every last decision or assessment to be closely scrutinized. Also, the PM will know the capabilities of the specialists and functional personnel required to complete the evaluation because of his interaction with the participating commands. In the end, it will be the management deficiencies or short comings which will probably distinguish one contractor from the other, and in that area,no one will be better qualified to make the required subjective judgment than the Project Manager for the XM1, Tank System.

SUMMARY

In this paper, an effort has been made to examine the XM1, Tank Program to determine the issues and potential problem areas facing the Program Manager, as he guides the development and production of this weapon system. The environment exerts strong schedule, cost, and performance constraints on the program.

The XM1 program is considered a moderate risk program, since many of the components have been in development for sometime, as independent research and development efforts, or as part of the ill-fated joint US/FRG MBT-70 program. As a result, the XM1 development is likely to be plagued by the memories of the MBT-70. By conducting a Competitive Prototype Validation Phase, with General Motors and Chrysler Corporation competing, the U. S. Army can be assured of maximum performance for the least cost because both contractors are experienced in tank development field.

Examination of the environment, the MBT-70 history, and the XM1 System Development Plans, indicates the issues and problem areas may be classified in two broad categories; ie, Technical, and Management Review and Approval.

The technical issues to be resolved are:

1. Are the Reliability, Availability, Maintainability, and Durability values set in the DCP, as thresholds, actually attainable?

2. Is it really in the U. S. best interest to consider the use of foreign components and technology?

3. Are the subsystem components being considered actually moderate risk approaches?

4. What is the maximum protection achievable within the maximum weight established?

The management review and approval issues to be resolved are:

1. What is required to meet the threat?

2. Is it desirable to fund two contractors through Full Scale Engineering Development to obtain the best tank for the money?

3. What type of contract is best for the Production Phase?

4. What criteria will be employed during the Competitive Validation Phase to evaluate and finally select one of the prototypes for Full Scale Engineering Development?

Considering all of the issues, the key issue is the criteria to be used to evaluate and select the winning prototype tank. The importance and validity of the criteria cannot be over emphasized considering the procurement is well over $1 Billion, and the XM1 will be a key ground weapon for the remainder of this century.

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